Mr. Rogers' Syllabus for AP Physics C: Mechanics

What to Expect:

You have begun a mental journey to an exciting new territory -- the world of physics. Like mountain climbing the journey takes effort and self discipline but the view can be awesome. Physics is not just a collection of facts. It is the search for the basic principles behind the facts.

These principles are often expressed as mathematical equations or models which makes applied physics or engineering amazingly effective for designing and improving equipment. Computers, for example, double in power every 18 months due to the fact that they're designed using applied physics.

Your reward for venturing into the world of physics will be a sharper mind and deeper understanding.

This is a calculus based, college level, physics class which covers mechanics for the American College Board AP Physics C Mechanics exam. Students passing this test may receive college credit. In addition, this class begins a two year course Physics course which covers the entire AP Physics C curriculum, as well as the IB Physics HL curriculum. The test schedule is as follows:

Year	Test
1	AP Physics C Mechanics
2	AP Physics C E&M IB Physics SL or HL

The Psychology of Physics Problem Solving
A teacher can guide students through a complex physics problem merely by asking questions. By learning to ask questions of yourself, you can gain the same level of problem solving skill without having a teacher present. It's called metacognition and is a skill you will acquire.

Powerful physics problem solvers also frequently use a type of free association. By learning to associate small hints with a corresponding physics principle, they can often visualize an equation for a problem even before they have fully read it. Again it's a skill that can be learned.

Who Should Take this Class: Students with highly developed algebra skills and an interest in careers related to: **engineering, the computer professions, medicine, physics, chemistry, or math.**

Credit: One unit of lab science

Prerequisites: Calculus concurrent or math teacher recommendation and parent override. A PSAT score in math of 60 or higher is a strong sign that you have the background needed to succeed in this course, but is not a requirement.

Use of Calculus: This course does make significant use of calculus, however, it's limited to relatively simple applications. On the other hand, a high level of skill in algebra is essential.

Extra Credit Opportunity--Science Fair

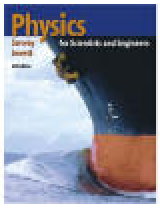
Grading and Assignments

Grading: (For details see Mr. (name omitted)' Syllabus - Information Common to All Classes.) Tests will be the single largest item and will be written as close to AP exam standards as possible. Course work will generally be finished in the third quarter leaving the rest of the year for review and various physics investigations (labs). The first semester exam will be taken directly from old AP tests. The exam grade will give you an indication of your standing on the future AP exam in enough time to take corrective action if needed. The fourth quarter grade will consist primarily of practice AP test grades. Generally, there is a high correlation between the practice exams and your grade on the AP test.

Group Project: All juniors have to participate in a group science project to meet the school's standards. This requires a minimum of 10 hrs of time outside of class and requires a student to design, conduct, and analyze a physics experiment as part of a team. Students must keep a log of their time and turn it in. The project is to be presented as a science fair project with a backboard. Projects deemed worthy will be sent to the regional science fair and earn extra credit.

Resources and Materials for Class

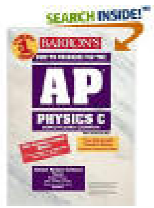
Textbook : Mr. (name omitted) will provide the following books:



Physics for Scientists and Engineers
by Raymond A. Serway, John W. Jewett **Publisher:** Brooks Cole; 6 edition (July 21, 2003)

ISBN: 0534408427

How to Prepare for the AP Physics C (Paperback)
by Robert A. Pelcovits, Joshua D. Farkas



Web Page Resources Provided by Mr. (name omitted)
All of the following are maintained by Mr. (name omitted) and can be reached via links from his teacher homepage.

1. **Objectives:** The daily objectives used in class along with homework assignments are all available online
2. **Practice Tests:** Self scoring online practice tests complete with explanations of the answers are available for each unit. In addition practice test questions without answers are also available online. You should have no surprises when you take tests.
3. **Study Guides:** Study guides are available online for each unit. These include the equations you must learn, problem solving tips, important concepts, vocabulary lists, and example problems to help you succeed on tests.
4. **Movie Physics:** Mr. (name omitted) maintains a web site with all kinds of movie physics information to assist you in your enrichment assignments.

Physics Software
Interactive physics software will be available in the physics classroom for conducting simulations and confirming solutions to problems

Materials for Class Provided by the Student

Physics Investigations - Labs: We will be spending about 20% of our instructional time on various forms of physics investigations. These will include formal lab write ups, mini-labs (informal write ups), and a few after school labs.

We will also analyze several Hollywood movie scenes in class and while these differ in some ways from conventional labs, they still involve the measurement of quantities like time, distances, and angles just like ordinary labs. They have an added element in that it is often necessary to scale the measurements by estimating the size of objects in the video and the camera angles. In other cases, we will help answer questions about movies by using simulations with computer software or an anthropomorphic dummy.

Many investigations will be conducted with computerized data collection using a wide range of Vernier Lab equipment, video analysis, and sophisticated devices like air tracks. Other labs will use old fashioned meter sticks, stop watches, pendulums, spring scales etc. At least some of the labs will be designed by students.

All physics investigation raw data and observations will be recorded in a bound composition notebook which will be periodically checked. Write ups will be maintained in an electronic portfolio (computer folder) and be submitted via the school's computer network.

Enrichment Assignment: You cannot master physics if you only think about it in the classroom. To encourage physics thinking in everyday life, once per quarter you are to review a Hollywood movie scene for physics content. The review will contain the following:

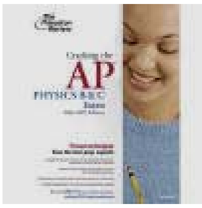
1. The movie's title and main stars.
2. A summary of the scene (about one good paragraph)
3. A summary of the scene's physics (about one good paragraph)
4. At least one calculation related to the scene's physics

To analyze movies you will have estimate many of the parameters used in your calculation, often based on the size of objects in the movie. Estimating is a real world skill which is often required for major engineering projects.

The analysis is to be submitted via the school's computer network as a computer file one week before the end of each quarter and will count as a lab grade. The file is to be labeled with the movie name and your

1. **A USB thumb drive** or other storage media for maintaining your electronic portfolio of physics assignments.We will attempt to be as close to a paperless classroom as possible.

2. **A bound composition book** for recording raw data and observations during physics investigations
3. **A set of dry erase markers**. You will frequently be working problems in class on a white board.
4. **A graphing calculator**
5. **Cracking the AP Physics B and C Exams, 2006-2007 Edition (College Test Prep) (Paperback)** by Princeton Review , **$12.35** from Amazon.com, can generally also be purchased locally. **Note: this book is the text for IB physics topics.**



name and can be either be an a Microsoft Word or Excel file.

Class Work
You cannot master physics by watching Mr. (name omitted) work problems, hence, you will be going to the front of the classroom and working problems on the white board in groups of 2 on a regular basis. Guided practice of this type is a powerful learning opportunity. In this class you will think physics, talk physics, write physics, and yes at times even help teach physics to your fellow classmates.

Mr. Rogers' AP Physics C: Mechanics Objectives				
Syllabus	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Kinematics(1)	Vector Addition(2)	Projectile Motion(2)	Newton's Laws(3)	

Kinematics

AP Physics C Newtonian Mechanics:

A. Kinematics (vectors, coordinate systems, displacement, velocity, and acceleration) approx

1.Motion in one dimension
2.Motion in two dimensions including projectile motion

Practice Test	Study Guide
Objectives	**Activities**
	Lesson 1

Essential Question: **Is physics true?**

Key Concept: Physics is made up of models. Average speed and velocity are significantly different because one is a scalar and one is a vector.

Models, Frame of Reference, Vectors and Scalars

1. Explain why models do not perfectly describe reality.
2. Define kinematics and state why it must always have a frame of reference.
3. Calculate average speed & solve speed problems.
4. State the difference between average and instantaneous as applied to kinematics.
5. State the difference between vectors and scalars.
6. State the difference between distance and displacement.
7. State the meaning of the sign on a vector.
8. Calculate average velocities.

Homefun: Questions 1, 2 p.49 Write a paragraph describing a scene from a sport assuming the frame of reference is on the ball

Metacognition Problem Solving Principle: Always attempt to estimate upper and lower limits on a variable in order to evaluate whether it has been correctly calculated.

In real life there are no answer books. Determining if a solution is right or wrong is up to you

Purpose: Introduce physics as a science of modeling by using several models.

Pre-assessment: Use the internet to answer questions 15 - 17 on the Basic Physics Savvy Quiz

Interactive Discussion: Objectives 1. A model is a simplified version of reality used for predictions. A Barbie doll is a model. What things can be predicted from Barbie? In what ways is she simplified?

Interactive Discussion: Objectives 2-3.How can a stationary wall also be moving at nearly 1000 miles per hour? What concept in physics accounted for the difference between Ptolemy's geocentric model of the universe and Galileo's model (two person groups using internet)? Both can accurately predict the location of planets in the night sky.

Interactive Discussion: Objectives 3 - 7, What is velocity? What is a vector? What is the difference between average speed and average velocity?

Resources/Materials: Barbi Doll, VCR, The Abyss video, computers for internet access.

Essential Question: **What is the difference between the common use of the term acceleration and the physics use of the term?**

Lesson 2

Key Concept: Even a high quality model has errors which creep in due to simplifying assumptions and experimental errors.

Acceleration

9. For constant velocity, draw the v vs t, and x vs t curves.
10. Define acceleration.

Purpose: Create kinematic model of an event..

11. Calculate average acceleration.

Metacognition Problem Solving Principle: All the members of a group need to make the calculations. When there is agreement the calculations are usually right.

Interactive Discussion: Objectives, What does the slope and intercepts mean on the graphs in obj. 9? Introduce lab write-up standards and the concepts of errors in the model and experimental errors.

Interactive Discussion: Objectives 10, What is acceleration? In what types of situations would average accel differ from instantaneous accel? When would the two be equal? What does a negative acceleration mean?

Closing: Are models in physics accurate or are they merely adequate?

Movie Scene Analysis (3 person groups): *The Abyss,* Scene where Harrison falls over an underwater cliff.

1. How could we determine if he falls at constant speed?
2. What is the difference between his instantaneous and average speeds?

Resources/Materials: VCR, The Abyss video, stop watches, computers for use with Excel Spread Sheets.

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Abyss Analysis (groups of three)
Purpose	Determine if it is reasonable to model Ed Harris' fall as constant velocity.
Overview	Record the distance and time during the fall. Use an Excel Spread

Data, Calculations	1. What factor would cause him to fall at constant or variable speed? 2. If he fell at variable speed would it most likely increase or decrease? 3. What is his frame of reference and would it change his speed if it were changed? 4. How could we mathematically indicate whether he is moving up or down?
Resources/Materials:	Abyss video, stop watch

Essential Question: Why are constant acceleration problems so common and of such importance?

The Constant Acceleration Kinematics Equations

12. For constant acceleration, draw the a vs t, v vs t, and x vs t curves and write equations for each.
13. State the meaning of the slope at a point for the v vs t, and x vs t curves.
14. Solve constant acceleration problems in one dimension. using the kinematic equations:

$v_f = at + v_o$

$x = 1/2\ at^2 + v_o t$

Remember, the above 2 equations are only good when acceleration is *CONSTANT* !!!

15. State why all objects fall at the same rate of acceleration.

Homefun: Questions 3 - 15 p.49; prob 1, 3, 5, 7, 9

Metacognition Problem Solving Principle: Whenever possible draw a picture or sketch a graph of the problem. Pictures tend to engage additional parts of the brain not stimulated by equations

Lesson 3

Key Concept: Many useful real world problems can be modeled as having constant acceleration

Purpose: Learn to solve constant acceleration problems

Interactive Discussion: Objectives.The 2 constant acceleration equations.

In Class Problem Solving (2 person groups)**:** Constant accel problems

1. Bob stops the redneckmobile
2. Toto in the well
3. Bambi on the highway
4. Robin Hood shoots a flaming arrow

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Analysis of human reaction time (groups of two)
Purpose	To estimate human reaction time by using a falling object..
Overview	Have one person drop a meter stick between the other's fingers. Do not allow the fingers to touch the stick before it drops. Measure the distance the stick falls before being "caught". Calculate your reaction time based on 5 trials. Calculate an average reaction time for the entire class.
Data, Calculations	Would it make a difference in reaction time if one of the subject's fingers were touching the stick at the time it was dropped? Explain. How much would reaction time affect the accuracy of the time obtained using a stop watch.
Resources/Materials:	meter sticks

Essential Question: What does the slope mean?

Derivatives

16. State the general meaning of a derivative.
17. Find the derivative of a polynomial.
18. Given x = f(t) or v = f(t) find v = f(t) or a = f(t).

Metacognition Problem Solving Principle: Most problems in physics are solved by simply writing enough equations so that they can be solved simultaneously.

Lesson 4

Key Concept: The derivative is simply the slope at a point. Velocities and accelerations are both derivatives.

Purpose: Work problems using the derivative of polynomials

Interactive Discussion: Objectives 15 - 17 What is a derivative and how does it relate to physics.

In Class Problem Solving: Constant acceleration problems

1. Batman punches accelerator
2. Batman slams brakes

Interactive Discussion: Objectives

Resources/Materials: color markers, white board.

Essential Question: What does the area under a curve mean mean?

Lesson 5

Key Concept: The integral is simply the area under the curve.

Integration

19. State the general meaning of integration.
20. State the meaning of the area under the curve of the a vs t and v vs t curves.
21. Given a = f(t) or v = f(t), find v = f(t) or x = f(t).
22. By looking at the direction of the velocity and acceleration vectors, state whether an object is slowing down or speeding up.
23. Given mass calculate weight.

Homefun: 2.35, 2.37, 2.41, 2.49, 2.59 p.53 - 52

Metacognition Problem Solving Principle: Always list and pay attention to units. This will help prevent algebra errors.

Purpose: Work problems using the integration of polynomials

Interactive Discussion: Objectives. What is integration and how does it relate to physics?

Demo 1: Show carpenter's form

In Class Problem Solving: integration problems

1. Reverse Batman punches accelerator
2. Reverse Batman slams brakes

Interactive Discussion: Objectives 21 -22. Why is mass not the same thing as weight?

Demo 2: Drop book with sheet of paper on top.

Resources/Materials: carpenter's form, color markers, white board.

Formal Physics Investigation	
Title	Lego Robot Investigation I
Category	Mechanics
Purpose	Determine if a Lego Robot travels at constant velocity
Models	v = dx/dt
Overview	Build a Lego Robot (the design is your choice). Test it to see if it runs at constant velocity. Draw an x vs t curve and use linear regression to find a line of best fit.
Safety Issues	Small plastic parts on the floor are a tripping hazard.
Equipment Limitations	The small motors will burn up if they are connected to a power source and not allowed to turn freely.
Resources/Materials:	Lego Robotics kit, meter sticks, stop watches, masking tape

Chapter 3: Vector Addition

Students measuring a fan's velocity profile

AP Physics C Newtonian Mechanics:

A. Kinematics (vectors, vector algebra, components of vectors) approx 6% cumulative 12%

1. Motion in one dimension
2. Motion in two dimensions

Practice Test	Study Guide

Objectives	Activities
Essential Question: Is 1+ 1 = 2 always true ? **Vector Addition Basics** 1. State the relationship of a force's direction to the resulting acceleration's direction. 2. State the relationship of a velocity's direction to the resulting displacement's direction. 3. Sketch 2 ways to graphically add vectors. 4. Define vector components. 5. Given vector components find the resultant vector and its angle. 6. Given a vector find its components. **Homefun: Questions 1-14 p.70, Read Chap. 2; Serway**	**Lesson 1** **Key Concepts:** 1) certain types of vectors always go in the same direction. 2) Vectors can be added graphically. 3) Vectors can be broken into components. **Purpose:** Add vectors. **Interactive Discussion:** Objectives. Which types vectors always go the same direction? How are two vectors added in one dimension? **In Class Problem Solving:** Vector Addition 1. Erie Canal Problem 2. Airplane Problems **Etch-a-sketch Demo**: Add vectors with the etch-a-sketch. Show components and how they look when added together. **Interactive Discussion:** Objectives Find components and angles graphically. Derive mathematical formulas for components. Find components mathematically. **Resources/Materials:** Protractors, etch a sketch

Essential Question: What is the fastest way to swim across a raging river?

Using Vector Components

7. State the relationship between the magnitudes of vector components.
8. Solve problems involving adding or subtracting 2-vector components.

- Swimmer problems
- Airplane problems

Homefun: problems 7, 17, 23, p.71 - 72; Serway

Metacognition Problem Solving Principle: When adding two vector components (from different dimensions), the resultant is always less than the sum of the components magnitudes but always greater than the smallest components magnitude.

Lesson 2

Key Concept: The x and y components are independent
Purpose: Solve vector problems involving components.

Interactive Discussion: Objectives. Introduce the running bear problem .

In Class Problem Solving: Vector problems

1. Add two components.
2. Given a vector, convert it to components.
3. Running Bear

Essential Question: How can an airplane's speed be measured?

Special Vector Notation

9. Use unit vectors (i, j, k).
10. Add multiple vectors together using the three step component method.

Homefun: problems 47, 49, 53, 61, p.74-75; Serway

Lesson 3

Key Concept: Multiple vectors at various angles can be added using components
Purpose: Add multiple vectors.

Interactive Discussion: Objectives. Discuss i, j, k unit vector notation and addition. Show three step method

In Class Problem Solving: Vector problems

1. Running Bear (continued)
2. Airplane Problems - ground speed
3. Three vector addition

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Analysis of Wind Tunnel Fan's Output
Purpose	Measure the ACFM output of a wind tunnel's fan and compare it to the factory's specification.
Overview	1. Divide the fan into annular rings with the same width (about 4-5 inches wide). 2. Measure the air flow velocity in the annular rings at 4 positions--top, bottom, right side, left side--and average the measurements. 3. Multiply the average air flow velocity for each of the rings by the area of the ring to obtain the volume flow rate for each ring. 4. Sum up the volume flow rate for each ring. This gives an estimate of the total volume flow rate for the fan. 5. Convert to the correct units. Note: according to the factory, the fan's volume flow rate = 13,000 ACFM
Data, Calculations	Calculate a % difference between the measured and factory specification of volume flow rate.
Questions, Conclusions	What would happen to the accuracy of the measured value if it was calculated using many more rings. (Assume the velocity measurements in any sized ring is perfect) Why is the velocity in the outer ring higher than the inner rings?
Resources/Materials:	Wind tunnel with fan, air velocity probe,

Chapter 4: Projectile Motion

AP Physics C Newtonian Mechanics:

A. Kinematics (vectors, vector algebra, components of vectors, coordinate systems, displacement, velocity, and acceleration) approx 6% cumulative 18%

2. Motion in two dimensions including projectile motion

E. Circular motion and rotation approx 6%, cumulative 24%

1. Uniform circular motion

Objectives	Activities
Essential Question: If Bob stands on the edge of the Grand Canyon and throws a penny straight down, why or why not is the penny in freefall? If he threw the penny horizontally would it be in freefall?	**Lesson 1** **Key Concepts:** Projectile motion as a form of freefall.

Forms of Freefall

1. Define freefall.
2. Define projectile motion. (An object in freefall given a starting velocity.)
3. State the type of curve a projectile will follow when given constant velocity in one dimension and constant acceleration in another. (Parabola)
4. State the name of the path a projectile follows. (Trajectory)
5. State the acceleration in the x and y dimensions for projectile motion.
   - x-dimension accel = 0 always
   - y-dimension accel = 9.8 m/s/s on Earth always
6. State the condition of velocity in both the x and y dimensions.
   - x-dimension velocity = constant always
   - y-dimension velocity = variable always
7. State the relationship of the velocity & acceleration vectors in the x direction to those in the y direction.
   - INDEPENDENT

Homefun: Questions 1, 3, 5, 7, 9 p.100; Problems 9, 11, 13, 17 Serway

Purpose: Model projectile motion assuming no air resistance and constant acceleration in the y-dimension.

Interactive Discussion: Objectives 1-5.

Floppy Disk Projectile Demo: If the x and y dimensions are independent then two disks projected horizontally at nearly the same time should strike the floor at nearly the same time even if they have different velocities. (Place a floppy on the edge of a desk and knock it off with two floppies taped together so that all the floppies fly over the edge almost simultaneously.)

In Class Problem Solving:

1. Private Jackson drops a cannon ball when the cannon fires

Resources/Materials: 3 floppy disks, two taped together.

Essential Question: If we ignore air resistance is there any force to produce acceleration in the x-dimension and what does this tell us about x-dimension	**Lesson 2** **Key Concept:** The x and y components are independent

velocities?

Projectile Motion with Various Launch Angles

Bombs and Baseballs

8. Solve bomber problems.
   - Why did the Japanese use a high level horizontal bomber in WWII to sink the USS Arizona?
9. Solve baseball problems.
10. State the relationship between the range for projectiles launched at complementary angles with the same initial velocity.
    - Why would the Confederates use complementary angles to bombard Fort Sumter?

Purpose: Solve projectile motion problems with various launch angles.

Video Clip: Show a video clip of the Bombing of USS Arizona, *Pearl Harbor* Video

Interactive Discussion: Objectives. Review mini-lab results.

Group Problem Solving: Working in teams of two, calculate the ranges for angles from 10 to 80 degrees in increments of 10 degrees. List the findings in on the white board. Plot the results and state a conclusion.

Resources/Materials: *Pearl Harbor* Video

Essential Question: Does the force of gravity ever flip flop and what does this tell us about the acceleration due to gravity used in projectile motion calculations?

Projectile Motion with Different Launch and Landing Elevations

11. Solve projectile motion problems for various take off angles when the impact point is above or below the launch point.
    - the artillery problem of shooting down a balloon.
    - Jackie Chan jumps from roof to roof
    - Jackie Chan jumps from roof to balcony
    - Robin hood storms the castle.

Some Movies with Projectile motion:

- Speed
- True Lies

Lesson 3

Key Concept: Using components to take advantage of the independence of x and y dimensions.

Purpose: Solve projectile motion problems with various launch angles and with starting and ending points at different locations.

Interactive Discussion: Objectives. Projectile motion in movies--how it's really done. Why do jumpers need a landing ramp? Why are stunt drivers buckled into special suspension systems?

In Class Problem Solving: See list under objectives

- Back to the Future II

Essential Question: In WWII, why were bombers more effective at sinking ships than ships were at shooting down bombers?

Hitting Targets With Projectiles in the Real World

13. Describe the equations used to model air resistance.
14. Sketch the trajectory of a hypothetical projectile with and without air resistance.
15. Solve projectile motion problems when the target is moving.

- Why would a WWII bomber be difficult for a ship to shoot down?
- Why would dive bombers be more accurate than horizontal bombers?
- What factors would have made the the fatal shot in the Kennedy assassination easy, assuming it was fired by Oswald?

Lesson 4

Key Concept: To understand projectile motion is to gain a deeper understanding of history including WWII, the American Civil War, the Kennedy assassination etc.

Purpose: Give students an understanding of how complex projectile motion problems can become and on the part solving them has played in history.

Interactive Discussion: Objectives.

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Analysis of motorcycle jump in *True Lies*
Purpose	Determine if the bad guy could have survived the motor cycle jump without being injured.
Overview	The bad guy drives a motorcycle off the top of a sky scraper, flies across a roadway, and lands in a swimming pool on top of a shorter sky scraper. He is uninjured.
Data, Calculations	Using your observations from the movie: 1. Calculate how far the bad guy falls by measuring the time of the fall and making appropriate assumptions. 2. Estimate the bad guy's horizontal velocity (assume the motor cycle's max velocity is 0.5 g on top of the building. measure the corresponding time and calculate final x-velocity.) 3. Estimate how far the bad guy travels horizontally during the jump. (Use objects in the movie for the scale or multiply x-velocity times time.).

	4. Estimate the bad guy's total velocity on impact. (Convert this to miles per hour.)
Questions, Conclusions	Is it likely that the bad guy could have walked away uninjured?
Resources/Materials:	True Lies Video, stop watches

Essential Question: What is the single biggest reason to use a computer for modeling projectile motion problems?

Computer Analysis of Projectile Motion

16. Solve Projectile motion problems with a computer simulation (Interactive physics)

Lesson 5

Key Concept: How Computers are Used for Projectile Motion Problems
Purpose: Introduce students to the modeling of complex problems.

Interactive Discussion: Objectives.

In Class Problem Solving: See Mini-Lab below.

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Analysis of Bus jump in *Speed*
Purpose	Determine if the bus could have made the jump under the right circumstances.
Overview	In the movie a bus is depicted jumping a 50 ft gap in a highway overpass. Run the jump in slow motion and observe the jump. Pause the video at the gap and measure the take-off angle. Estimate a distance on the bridge and using a stop watch to obtain time estimate the bus's speed.
Data, Calculations	Calculate the bus's speed from the above data as well as its position when it crosses the gap (note that it could be below the edge of the bridge). Use both interactive physics and pencil& paper calculations to determine if the jump could have been made under the right conditions without wrecking the bus . Run the simulation both with

Questions, Conclusions	1. What assumptions in the hand calculations would be likely to introduce significant errors. 2. Does inclusion of air resistance in the simulation significantly affect the results? 3. Could the bus have made the jump exactly as predicted? Explain you answer both with observations you made of the video and with calculations.
Resources/Materials:	Speed video, protractor, stop watch, interactive physics software

Essential Question: Is a circular orbit a form of freefall?

17. State the direction of centripetal acceleration and force.
18. Compare circular to projectile motion.
19. Calculate centripetal acceleration.
20. State why centripetal acceleration is not constant.
21. Calculate period (T) of an object in centripetal motion.

$$T = (2\pi r) / v_T$$

Homefun: Problems 25, 27, 29 Serway

Lesson 6

Key Concept: Uniform circular motion results in radial or centripetal acceleration.

Purpose: Understand the similarities and differences between circular and projectile motions.

Interactive Discussion: Objectives. Define tangential velocity, centripetal acceleration and force.

In Class Problem Solving:

1. Vertical circle
2. Horizontal circle

Chapter 5: The Laws of Motion

AP Physics C Newtonian Mechanics: B. Newton's laws of motion Approx 10%, cumulative 34%

1. Static equilibrium (first law)
2. Dynamics of a single particle (second law)
3. Systems of two or more bodies (third law)

Practice Test	Study Guide

Objectives

Essential Question: Is mass in physics the same thing as the amount of matter present?

Newton's 3 Amazing Laws

1. Explain inertia and its relationship to mass. (mass = linear inertia)
2. Explain what is meant by an inertial frame of reference (Serway p.114).
3. Solve problems with Newton's 1st law (the bunny principle).
4. Explain Newton's second law (F = ma).
   - F = net Force
   - net Force is directly proportional to acceleration
5. State Newton's 3rd law in 3 ways.
   - Serway p.120
   - Can't touch without being touched
   - Forces always appear in pairs acting in opposite directions on 2 different objects.
6. Solve problems using Newton's 3rd law.

Homefun: Read 5.1 to 5.5

Essential Question: If forces always come in pairs, how can anything move?

FBDs, g, Acceleration, and Elevator Problems

7. Draw free body diagrams.
   - Generally shows the object as a square
   - Show only forces from the outside acting on the object.
8. State 3 ways "g" can be defined.
   - Acceleration of a free falling body

Activities

Lesson 1

Pre-assessment: Use the internet to answer questions 21 - 26 on the Basic Physics Savvy Quiz

Key Concept: Newton's laws, free body diagrams.

Purpose: Solving acceleration problems using free body diagrams.

Interactive Discussion: Objectives. What would the world be like if Newton's first law were turned off. In other words, what if motion required a net force to keep it going. A bus hits a bug. Which has the higher force a bug or a bus? Draw free body diagrams.

In Class Problem Solving:

1. Bob weighs himself on the elevator.
2. Bob pulls himself upward using a pulley and harness.
3. Jane drives her boat.

Lesson 2

Key Concept: Free body diagrams (FBD)

Purpose: Enable one to identify the forces that belong in a Newton's second law equation

Interactive Discussion: What causes the sensation of weight?

In Class Problem Solving: elevator problems

1. Bob stands on a scale in the elevator

- A unit of acceleration (freefall only)
- A gravity constant used for calculating weight force.

9. Explain which force causes the sensation of weight.
10. Solve elevator problems (both vertical and horizontal).

    - "g" is a gravity field strength vector not an acceleration.
    - "g" is negative because it points downward.

11. Solve elevator problems.
12. Solve 2 cable elevator problems.

Homefun: Read 5.6, prob. 1, 3, 29, 33, 51 p. 141-145 Serway

2. Bob's boat has water resistance.
3. 2 cable elevators

Essential Question: Can metacognition questions be used to start a problem as well as evaluate its answer?

Pushing, Pulling, and Cliff Hangers

13. Find the tension in the rope when one object is towing another.
14. Find the normal force between objects when one object is pushing another.
15. Solve *Jurassic Park* type suspended bus problems.

Metacognition Problem Solving Principle: A teacher can guide a student to the solution of a complex problem merely by asking questions, but first the student must first learn to answer rather than simply follow the teacher's instruction. Ultimately, the student can solve problems without the teacher by learning to ask himself or herself the questions. ***Problem solving is about asking questions.***

Homefun: Read 5.6, prob. 24, 31, 45 p. 141-143 Serway

Lesson 3

Key Concept: Free body diagrams (FBD)

Purpose: Enable one to identify the forces that belong in a Newton's second law equation

Interactive Discussion: Objectives.

Video Clip: Show a video clip of the bus hanging scene in *Jurassic Park*

In Class Problem Solving:

1. Towing problem
2. Pushing problem
3. Jurassic Park problem

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Analysis of an Air Track Slider Accelerated by a hanging weight
Purpose	Determine if simple mathematical models can predict the behavior of an air track slider accelerated by a hanging weight.
Overview	1. Place the slider on the air track. 2. Attach a string to the slider and thread it through a pulley at the end of the air track. 3. Attach a weight to the end of the string so that it hangs over the table. 4. Set up the photogate to measure velocity after the slider has traveled some distance from a rest position. By knowing the final velocity and distance the slider's acceleration can be calculated. Compare this acceleration to one calculated from theory. Assume the pulley at the end of the track along with the string

Data, Calculations	Calculate a % difference between the measured and theoretical acceleration
Questions, Conclusions	1. What is the maximum possible acceleration of the cart? 2. If your acceleration values are higher than the maximum possible, what is the likely source of the error? (Do NOT claim it's measurement error.) 3. Why should the measured value be less than the theoretical one?
Resources/Materials:	Air track and slider. Photogates computer system set up with Vernier LabPro software and Lab Pro units

Essential Question: Can we use redefining the x, y axis as a problem solving strategy?

Objects on Slopes

16. Find the normal and parallel components of the weight force for objects on a slope.
17. Find the angle of the slope where the normal component of weight exceeds the parallel component.
18. Solve for acceleration of objects on a slope (zero friction).

Homefun: 22, 69 p. 141-143 Serway

Lesson 4

Key Concept: Normal and parallel components on a slope

Purpose: Enable one to solve slope problems

Derivation: weight components on a slope.

In Class Problem Solving:

1. Toto on a slippery slope.
2. Tension in Toto's collar

Group problem solving: Plot the acceleration, normal, and parallel forces vs angle. Draw conclusions from the plots.

1. Box on a slope with angle changing
2. Box on horizontal ground being pushed with angle changing.
3. Box on horizontal ground being pulled with angle changing.

Formal Physics Investigation	
Title	Measurement of g Using an Air Track
Category	Newton's Laws
Purpose	Measure g using an air track
Models	kinematic equations, F = ma (Note: if kinematic equations can be used, then what do you know about the slider's acceleration?)

Overview	A slider can "fall" down the slope of an air track set at an angle with respect to the horizontal. You are to devise an experiment for determining the value of g by using the air track and other equipment provided.
Safety Issues	Air track motors can overheat if the air inlet is blocked.
Equipment Limitations	Air tracks an their sliders are much more delicate than they look. Do NOT drop or strike them
Resources/Materials:	Air track and slider. Photogates computer system set up with Vernier LabPro software and Lab Pro units

Essential Question: What do civil engineers do? Why did the Twin Towers collapse?

Statics (the first half of the story)

19. State the force conditions required for static equilibrium.

$$\Sigma F_x = 0, \Sigma F_y = 0, \Sigma F_z = 0$$

20. Solve static equilibrium, cable problems. (buzzard problem)
21. Solve static slope problems.

Homefun: prob. 21, 27, 35 p. 141-143 Serway

Lesson 5

Key Concept: Static equilibrium

Purpose: Solve static cable problems.

Interactive Discussion: Can the tension in a rope be greater than a perpendicular force exerted in its center it?

In Class Problem Solving:

1. Buzzard problem
2. Stop light problem

Mr. Rogers' AP Physics C: Mechanics Objectives

Syllabus	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Newton's Laws (4)	Friction (5)	Mech Energy (7)	Momentum	Semester Exam

Chapter 5 (Continued): The Laws of Motion

AP Physics C Newtonian Mechanics:

B. Newton's laws of motion approx 5%, cumulative 39%

1. Static equilibrium (first law)
2. Dynamics of a single particle (second law)
3. Systems of two or more bodies (third law)

Objectives

Essential Question: Can you push with a rope?

Cable Problems

22. State the nature of idealized massless ropes used with friction free massless pulleys.
    - can pull but not push
    - tension in the rope is uniform throughout.
    - zero force is required to accelerate the rope
22. Draw freebody diagrams of accelerating objects attached with ropes.
23. Solve various cable problems.
24. Derive the equation for finding g using an Atwood machine.
25. By studying the equation decide the best strategy for setting up the Atwood machine for the most accurate results.

Homefun Complete the Atwood machine lab

Activities

Lesson 6

Key Concept: Atwood machine.

Purpose: Measure the gravity field constant g

Derivation: Atwood machine

In Class Problem Solving:

1. Atwood machine
2. Pulley on an icy slope
3. Jackie and Samo on a slope

Formal Lab Investigation	
Title	Estimating g using an Atwood machine
Category	Newton's Laws
Purpose	Determine if the gravity constant really is 9.8 m/s/s.
Models	Atwood equation: $g = a(m_1 + m_2)/(m_1 - m_2)$ Kinematic equation: $a = 2D/t^2$
Overview	After attaching a pulley to a fixed point, we hook masses to the string over the pulley. We then lower one of the masses until it touches the floor. We finally release the lower mass and time the descent of the higher mass, measuring this time and, through our equations, determining the gravitational constant.
Safety Issues	Be careful to regulate the descent of the higher mass so that it will occur slowly and not crash to the floor.
Equipment Limitations	Possible equipment limitations include friction between the pulley and the string, which will slow the rate of descent of the mass. This friction can be

	minimized by using a low-friction string or by greasing the pulley. Air resistance is a source of error that cannot be prevented, although its effects should not be substantial. The size of the error can be estimated by evaluating the differences between estimated values and the predicted gravitational constant.

Chapter 5 (Continued): Friction

AP Physics C Newtonian Mechanics:

B. Newton's laws of motion (friction) approx 5%, cumulative 44%

Practice Test	Study Guide
Objectives	**Activities**
Essential Question: Is friction a necessary ingredient in our world?	**Lesson 1**
The 3 Models for Friction 1. **Describe static friction.** • **Prevents** sliding between surfaces • **Variable** - adjusts to match the force which would otherwise cause sliding (the parallel force). 2. Correctly use the model for calculating static friction. $F_r = F_p$ 3. Correctly use the model for calculating the transition point between static and dynamic friction. $F_r = \mu_s F_n$ 4. Describe the relationship of normal force to transition point between static and dynamic friction and describe how this knowledge is used with fasteners.	**Key Concept:** Static friction **Purpose:** Understand the variable nature of static friction and the meaning of the static friction force. **Interactive Discussion:** Objectives 1-4. Note that the mathematical model for static friction calculates the maximum value and that there is no effect from surface area. **Demo 5.1:** Special pipe with rough and smooth surface - object: Friction is a highly complex phenomenon. Simple explanations like surface roughness do not explain it. **Demo 5.2:** Attach a large spring scale to a weight on a table and pull it horizontally. Do not allow the weight to move. For each reading of the scale ask what the static friction force is. - object: static friction force adjusts to match the pulling force. **Demo 5.3:** C-clamp and wood block - object: increasing normal force increases the maximum

5. **Describe dynamic or sliding friction.**

- **Resists** sliding between surfaces
- **Constant** for a give normal force

6. Correctly use the model for calculating the dynamic friction.

$$F_r = \mu_d F_n$$

7. State which form of friction tends to be lower.
8. Be aware that there are actually 3 different mathematical models for friction (see above).
9. State the relationship between contact area and friction (Hint: contact area is not in any of the 3 equations).
10. Solve flat bed problems.

static friction force.

In Class Problem Solving:

1. Jeb's flat bed truck accelerates with his dog Blue in the back.
2. Jeb slams on the brakes with Blue on the roof.

Demo 5.4: Place a heavy object on a piece of paper and slowly pull on it. The weight moves with the paper. Jerk the paper quickly and the paper moves but the weight stays in virtually the same location. - object: An object resting on a second object will accelerate

Resources/Materials: Special pipe with rough and smooth surface, C-clamp and wood block, video Speed II.

Homefun: Read section 5.8, Prob 37, 39 p.143-149

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Speed II (groups of three)
Purpose	Determine if the heroes would fly through the window of the ship during its collision with the dock.
Overview	A large ship crashes into a dock while the first mate calls out the ship's speed. The movies heroes crash through the windshield of the ship during the collision. By measuring the time as the first mate calls out the speed, it's possible to plot a velocity vs. time curve.
Data, Calculations	• Plot a velocity verses time curve for the ship and estimate the acceleration when the heroes fly through the windshield. Use linear regression. • Draw a free body diagram of the heroes just before they go through the windshield. • Model them as though they can only experience linear motion and estimate the size of the friction force needed to restrain them. • Calculate the maximum static friction force for the heroes assuming that the heroes have a mass = 80 kg and static m_s =0 .5

Questions, Conclusions	1. Is Hollywood movie time the same real time? Why or why not would it differ? 2. Given the above calculations, were the people aboard the ship in danger? Explain.
Resources/Materials:	Speed II video, stop watches

Essential Question: Can the friction force cause an object to accelerate?

Friction and Transportation

11. State the force which moves people when they walk.
12. State the key advantage in tug-of-war assuming COF for both teams is equal.
13. State the force which moves a car.
14. Calculate the maximum acceleration of a car given the coefficient of friction.
15. Calculate the maximum slope a vehicle can climb given static COF

Homefun 40, 41, 43 p. 143-149 Serway

Metacognition Problem Solving Principle: In many cases maximum static friction provides the limit on a system's acceleration.

Lesson 2

Key Concept: The role of static friction in moving people and vehicles

Purpose: Illustrate the similarity of equations for the maximum acceleration of walking and vehicles on flat ground and on slopes

Interactive Discussion: Objectives 6-7.
Demo 5.3: Tug of war between two people, one with friction, one without - object: Friction between the participants and the ground is the key factor in tug of wars.
Objectives 6-7.
Demo 5.4: Wheel with marking pen attached.- object: show that the friction between a wheel and the ground is static friction

In Class Problem Solving: Objectives 9. Simultaneously list the following problems:

1. Old Blue sliding in Jeb's flatbed
2. Max accel for the truck
3. Max stopping accel for the truck
4. Max centripetal force on the truck

Interactive Discussion: Objective 10. Derive an expression for the maximum slope a vehicle can climb. Is mass a factor?

Resources/Materials: Rope with handles on end and chair with wheels, tape and marker

Essential Question: At what angle does the parallel component of a object on a slope exceed its normal component?

Lesson 3

Key Concept: Changes in normal force interact with friction

Friction on Slopes

16. Solve problems involving kinetic friction on slopes.
17. Solve F=ma problems involving kinetic friction on horizontal surfaces with pushing or pulling forces at various angles.
18. Solve stacked block friction problems on horizontal surfaces.

Homefun 45, 47, 53, 67, 71 p. 143-149 Serway

Purpose: Illustrate how slopes and forces at differing angles affect kinetic friction and acceleration.

Group problem solving: Plot the acceleration, normal, friction, and parallel forces vs angle. Draw conclusions from the plots.

1. Box on a slope with angle changing
2. Box on horizontal ground being pushed with angle changing.
3. Box on horizontal ground being pulled with angle changing.

In Class Problem Solving: Slope problems

1. Fireman's rescue.
2. Jackie slides down a slope
3. Superman pulls Lois up a ramp.
4. Stacked boxes.

Formal Lab Investigation	
Title	The Effects of Friction and Drive System on Vehicle Performance
Category	Mechanics
Purpose	Determine if the maximum slope a motorized Lego vehicle is able to climb can be determined from the static COF and the drive system type.
Models	$\beta_{max} = \mathrm{Tan}^{-1}(\mu)$; $\mu = F_f / F_n$ Note: for tracked and four wheel drive vehicles $F_n = mg$. For two wheel drive vehicles $F_n < mg$.
Overview	Using the Lego Robotics kit construct a tracked vehicle. Measure the weight and static friction force of the vehicle using a spring scale. Next, measure the largest angle of the slope the vehicle can climb. Repeat the process twice, once for a four wheel drive vehicle and once for a two wheel drive vehicle. In each case, strive to keep the gear ratios the same.
Safety Issues	Lego Robots can be a tripping hazard if left on the ground.
Equipment Limitations	When sending electric current to the motors, make sure their wheels are turning! If not, the motors will burn up. Do not allow the wheels and tracks to spin any longer than absolutely necessary. They will wear out.

Chapter 7 & 8: Mechanical Energy

AP Physics C Newtonian Mechanics Standards

C. Work, energy, power 14 % cumulative 58%

F. Oscillations and gravitation 9%, cumulative 61%

1.Simple harmonic motion (dynamics and energy relationships)
2.Mass on a spring
3.Pendulum and other oscillations

Practice Test	Study Guide
Objectives **Essential Question: Can energy be defined?** **The Nature of Work** 1. Define mechanical energy. • **Position** • **Motion** 2. Correctly use the SI unit of energy. 3. Define work 3 ways. • **In words:** mechanical energy transfer done by a force acting through a displacement in its same dimension • **Mathematically:** $W = \int F_{(s)} \cdot ds$, • **Graphically:** work is the area under a force vs. displacement curve. 4. State whether work and mechanical energy are vectors or scalars. 5. State 2 requirements for work to be done by a force. • **Motion** • **Non-zero force component in same dimension as motion** 6. Explain what a dot product (scalar product) is and how the concept relates to work. 7. Calculate the net work done by a constant force acting through a displacement. 8. Calculate dot products for the i j k form of	**Activities** **Lesson 1** **Key Concept:** Work is the mechanical energy transfer done by a force acting through a displacement in its same dimension. **Purpose:** Use work as a powerful problem solving tool. **Interactive Discussion:** Objectives 1-8. Note that net positive work tends to increase kinetic energy and net negative decrease it. **Demo 7.1:** Student holding a book. Is work being done? **In Class Problem Solving:** How much work is done by the superman force in each of the following: 1. Superman pushing a trunk with and without friction. 2. Superman lifting a trunk. 3. Superman swinging a trunk (assume no air resistance). **Interactive Discussion:** Objectives 9. Total work is the sum of the dot products in all the dimensions. **In Class Problem Solving:** 1. Superman pushing a trunk with a

vectors. 9. Explain why work cannot be done by a centripetal force? **Metacognition Problem Solving Principle:** While work is a scalar, it does have a relationship to spatial dimensions. Note that the components of forces and displacements in the same dimension do work. components in a different dimensions do not. This relationship is most evident when multiplying the i j k form of the vectors. **Homefun: Questions 1-10 odd p 209; Problems 1, 3, 5, 6 p. 209-210 Serway**	variable force 2. Superman lifting a trunk with a variable force **Interactive Discussion:** Objectives 10, 11. Derive the spring potential energy equation. **Resources/Materials:**
Essential Question: How are kinetic energy and work related? **The Nature of Kinetic Energy** 10. Define kinetic energy 2 ways • **In words:** the work needed to accelerate an object from rest to its current velocity. (The energy an object possesses due to its motion) • **Mathematically:** $K = 1/2\ mv^2$ 11. **Derive the equation for kinetic energy** from the equation for work, Newton's second law, and the kinematic equations assuming constant force and acceleration. 12. Explain the difference between positive and negative work. 13. Use the definition of kinetic energy and work in problem solving. **Homefun: Read 7.5, Problems 25 p. 211 Serway**	**Lesson 2** **Key Concept:** Kinetic energy and work are related **Purpose:** Understand that work is mecchanical energy transfer and that typically when work is done it either increases or decreases kinetic energy. **Interactive Discussion:** Objectives. **In Class Problem Solving teams of 2:** Derive the equation for kinetic energy and the kinematic equations
Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	

Purpose	Determine if a pendulum can be considered frictionless.
Overview	The law of conservation of energy (1st law of Thermodynamics) is as close to absolute truth as anything in all of science. If a pendulum can be considered frictionless then the potential energy at the top of the swing will exactly match the kinetic energy at the bottom. • Set up a photogate to measure velocity at the bottom of a pendulum's swing • Release the pendulum from a variety of different heights and measure its velocity at the bottom of its swing.
Data, Calculations	• Make a plot a kinetic energy at the bottom verses potential energy at the top. • Show a theoretical line on the plot.
Questions, Conclusions	1. Should the theoretical line be above or below the line of best fit for the above plot? 2. Why does the photogate not measure instantaneous velocity and how does this error impact the above plot.
Resources/Materials:	photogate, pendulum

Essential Question: Throughout history, how have springs enabled war? How have springs enable peaceful development? **The Nature of Spring Potential Energy** *(The Linear Spring as an Energy Storage Device)* 14. Calculate the net work done by a variable force. 15. Explain why the net work done in compressing a spring is always zero. 16. Derive the equation for the potential energy of a linear spring. 17. Plot the spring potential energy vs. displacement for a linear spring and compare it to the force vs. displacement curve. **F = - dU/dx** (the spring force at x) = (the slope at a point on the U vs x curve) **U = ∫$F_{(x)}$ · dx** (U at a given value of x) = (the area under the F vs x curve from 0 to x) or	**Lesson 3** **Key Concept:** The equations for springs can be used to model many common situations involving the storage and release of energy. **Purpose:** Use spring equations in problem solving. **Interactive Discussion:** Objectives. **In Class Problem Solving:** 1. Horizontal spring launcher 2. Catapult 3. Spring bumper 4. springs in parallel or series

(U at a given value of x) = (the work required to compress the spring) 18. Find the spring constant with springs in parallel or series. **Homefun: Read 7.4, Problems 19 p. 211 Serway**	
Essential Question: What would driving a car be like if it had no suspension system? **Spring and Mass Systems** 19. Define simple harmonic motion. • **periodic** • **restoring force magnitude** linear with respect to displacement • **restoring force direction** always toward the equilibrium position 20. Give an example of motion that is periodic but not simple harmonic. 21. Draw the energy diagram for a spring in simple harmonic motion (p. 232), define the equilibrium position and describe location along the masses path of: • max and min **velocity** • max and min **acceleration** • max and min **restoring force** • max and min **kinetic energy** • max and min **spring potential energy** 22. Explain why the mechanical energy in a ideal spring/mass system is constant. 23. Solve problems involving a spring mass system when the mass is not attached. **Homefun: Problems 11, 13, 15 p. 210 Serway**	**Lesson 4** **Key Concept:** Harmonic motion. **Purpose:** Introduce and define harmonic motion. **Demo 7.2:** The Mr. (name omitted) YoYo-object: give an example of simple harmonic motion and how it relates to resonance. **Interactive Discussion:** Explain simple harmonic motion vs periodic motion. **In Class Problem Solving:** 1. Find the maximum deflection a vertical spring can have without losing the mass, if the mass is not attached.

Formal Lab Investigation	
Title	Simple Harmonic Motion of a Spring and Mass System
Category	Energy

Purpose	Determine if the natural frequency of a spring and mass system can be predicted.
Models	Linear spring force equation: F = k (x) natural frequency of a mass & spring system: $f = 1/(2p)(k / m)^2$
Overview	Using a spring scale, measure the force required to deflect a spring various distances and plot force vs. displacement. From the above, determine the spring constant. Attach the spring to a ring stand so that it hangs vertically and attach a known weight to the end of the spring. Lift the eight up and release it so that the system vibrates. Measure the system's frequency. Calculate the system's frequency from the natural frequency equation using the mass and spring constant.
Safety Issues	Do not start the harmonic motion by pulling the mass downward and releasing it. This can launch the weight.
Resources/Materials:	spring, known weights, stop watch, spring scale

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Measurement of g Using a Pendulum
Purpose	Measure g using a simple pendulum.
Overview	Measure the length and natural frequency of a pendulum.
Data, Calculations	Calculate g and the % difference between the expected and measured values of g. Note an error of more than 10% indicates sloppy lab technique.
Questions, Conclusions	1. Would this same technique work on any possible planet? 2. Describe how you could use a different form of harmonic motion to measure mass even if floating (hopefully inside a spacecraft) deep in outer space where the gravity force was indeed near zero.

Resources/Materials:	pendulum, stop watches

Essential Question: For an athlete, is power the same thing as strength? **Power Basics** 24. Correctly use the SI unit of power. 25. Define power. **In words:** power is the rate of doing work or the rate of using energy. **Mathematically:** $P = W/\Delta t$ $P = dE/dt$ 25. Calculate the power requirements of a car driving up an incline at constant velocity. $P = F(\Delta x/\Delta t)$ Remember: $W = F(\Delta x)$ $P = Fv$ **Homefun:Read 7.8, Problems 39, 41 p. 212 Serway**	**Lesson 5** **Key Concept:** Power is work per unit of time. **Purpose:** Use power equations in problem solving. **Interactive Discussion:** Objectives **In Class Problem Solving** (two person teams): Calculate the power required to drive up various slopes at 65 mph and 35 mph. Assume no friction or air resistance.
Essential Question: How dangerous are falls? **The Nature of Gravitational Potential Energy & Conservative Forces Sec. 8.6** 26. Define gravitational potential energy 2 ways: • **In words:** the minimum work needed to move a mass from one position to another in a gravity field. • **Mathematically:** $U_g = mgh$ (for a	**Lesson 6** **Key Concept: Gravitational potential energy and conservative forces** **Purpose:** Solve problems in which mechanical energy is conserved. **Interactive Discussion:** Objectives **In Class Problem Solving** (assume no

constant gravity field)

27. Solve problems in which mechanical energy is conserved. In other words, there is no work done or mathematically:

$$(U_{s1} + U_{g1} + K_1) = (U_{s1} + U_{g1} + K_1)$$

Homefun:Read 81 & 8.2, Problems 1, 3 p. 240 Serway

friction) **:**

1. Bob slides down a slope
2. Robin hood shoots an arrow straight up. (His bow is a spring.)
3. Robin hood shoots an arrow at an angle. (His bow is a spring.)
4. Robin hood shoots an arrow over a cliff as he gallops on a horse. (His bow is a spring.)

Essential Question: We have a law: conservation of energy. Do we have any similar law for force?

Conservative Forces and Potential Energy Diagrams

28. Identify conservative forces (p. 218).

- work done is path independent
- work done moving thru a closed path = 0

29. Name two types of conservative forces. Note that the equations in objective 17 (p. 232) can be applied to both types of forces even if the forces are not linear with displacement:

- ideal spring force (no friction)
- gravity force

30. Be aware that potential energy can only be associated with conservative forces.
31. Correctly use the following equation (p. 219):

$Wc = Ui - Uf$

Where Wc = work done by a conservative force.

32. Solve problems using energy diagrams and the concept of stable and unstable

Lesson 7

Key Concept: Conservative forces and potential energy diagrams.

Purpose: Solve problems with potential energy diagrams.

In Class Problem Solving:

1. Potential energy vs displacement problems

equilibrium. **Homefun: Read chap 8.3 - 8.6, Questions 44, 45, 46 p. 245 Serway**	
Essential Question: Efficiencies aside, how could an electric car require less energy to operate than a gasoline fueled car? **Using Kinetic, Gravitational Potential Energy, Spring Potential Energy, and Work All Together With the First Law of Thermodynamics** 33. State the first law of thermodynamics. 34. Solve problems with all the forms of mechanical energy including mechanical energy transfer. 35. Be aware that sliding friction is not a conservative force and that when it does negative work it converts mechanical energy into heat. 36. Solve energy problems in which mechanical energy is converted into heat. **Metacognition Problem Solving Principle:** Energy problems are straightforward as long as you remember that all the energy in a system at the beginning of a problem has to still be there at the end, except for energy transferred into or out of the system using work. In equation form: (energy at start) + **(sum of work done by non-conservative forces acting on the system)** = (energy at end) or $(U_{s0} + U_{g0} + K_0) + (W_{ncf}) = (U_{s1} + U_{g1} + K_1)$ $W_{ncf} = \Delta K + \Delta U_s + \Delta U_g$ Note that work can be either positive or	**Lesson 8** **Key Concept: Conservation of energy.** **Purpose:** Use all the energy equations to solve problems. **Interactive Discussion:** Objectives **In Class Problem Solving** (friction present) **:** 1. Bob slides down a slope 2. Robin hood shoots an arrow straight up. (His bow is a spring.) 3. Robin hood shoots an arrow at an angle. (His bow is a spring.) 4. Robin hood shoots an arrow over a cliff as he gallops on a horse. (His bow is a spring.)

negative. Remember negative work decreases kinetic energy and positive work increases it. **Homefun: Problems 33, 49, 51, 63 Serway**	

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Measurement of Friction on an Air Track
Purpose	Estimate the friction force on an air track
Overview	Although air tracks come about as close to creating a zero friction environment as possible, they still have some. The results of any air track experiment could be improved by including friction in the mathematical models, but if the friction force is indeed very small, including it would have little effect on an air track experiment. To estimate the friction force we will assume that it is constant and that there are no energy losses in the spring when a slider rebounds. 1. Set up an air track at a known angle and place a slider at the top. 2. Release the slider and let it rebound off the bottom. 3. Record the height the slider rebounds to and calculate the change in height from the original position. Repeat the process several times and record your data.
Data, Calculations	Given the above assumptions and data, estimate the friction force acting continuously on the slider. (Hint: the friction force does work and in the process converts mechanical energy to heat. Write an energy balance equation) Construct a 95% confidence interval for your estimate of the friction force.
Questions, Conclusions	1. Devise an experiment to measure the mechanical energy loss in the slider's spring. 2. Devise an experiment to determine if the friction force on the track is indeed constant.
Resources/Materials:	air track

Essential Question: Are we energy beings?	**Lesson 9**
The Nature of the World's Most Famous Equation 37. Explain all the variables in the equation **$E = mc^2$** E = energy m = mass converted into energy c = speed of light, approx 3.0 (10^8) 38. Calculate the energy released if a quantity of mass is converted to energy. (one megaton of TNT = 4.184×10^{15} Joules of energy)	**Key Concept: Matter is condensed energy** **Purpose:** Use $E = mc^2$. **Interactive Discussion:** Objectives **In Class Problem Solving:** 1. Calculate the energy released by reacting 8 grams of anti-matter with matter.

Mr. Rogers' AP Physics C: Mechanics Objectives

Syllabus	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Gravity	Circular Motion	Statics	Rotation	

Chapter 6: Circular Motion p. 151

E. Circular motion and rotation 6% (estimated), cumulative 88%

1. Uniform circular motion

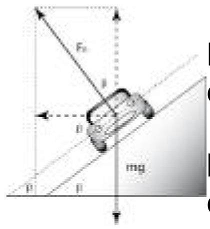
Practice Test	Study Guide

Objectives	Activities

Essential Question: **What is the difference between centripetal and centrifugal force and is centrifugal force real ?**

Lesson 1

Section 6.1, 6.2



1. Explain why centripetal force never shows up on a free body diagram.
2. Solve conical pendulum problems (horizontal circle).
3. Solve road bank problem given static friction = 0 (horizontal circle, see drawing at right).
4. Derive an expression for the critical speed of a roller coaster loop (vertical circle).
5. Derive an expression for the ramp height needed to achieve the critical velocity in a roller coaster loop (vertical circle).
6. Derive an expression for the tension in the rope used for swinging a mass at constant velocity in a vertical loop (vertical circle).

Homefun: Problems 13, 15, 21, 57, 55. Serway

Metacognition Problem Solving Principle 6.1: When solving a circular motion problem always ask which forces have components in the radial direction. The sum of these components is the centripetal force.

Metacognition Problem Solving Principle 6.2: All circles in the AP test will be either vertical or horizontal except for space stations in which case it doesn't matter. This is important since it indicates the plane which contains the radial direction (see **Metacognition Principle 6.1)**

Key Concept: Centripetal force is the sum of the forces directed toward the center of rotation.

Purpose: Gain a deeper understanding of the circular motion equations.

Interactive Discussion: Objective 1. Why does centripetal force never appear on a FBD?

Demo 1: Demonstrate the critical velocity in a vertical loop using a commercial loop track.

In Class Problem Solving: Objectiv**es.**

1. The conical swing.
2. Batman drives the Batmobile on a slippery slope.
3. The world's most exciting rollercoaster.
4. Loop the loop ramp height calculation.
5. Tarzan's amusement ride.

Resources/Materials: The loop the loop demonstration.

Essential Question: **Is a fictitious force something out of a novel?**

Lesson 2

Section 6.3

7. Explain how fictitious forces appear both in systems which are accelerating in linear and uniform circular motion.
8. Find the angle a rope makes when it is suspended from the roof of an acceleration rail car.

Metacognition Problem Solving Principle 6.3: The sum of the components in the dimension of acceleration provide the force causing linear acceleration.

Key Concept: Fictitious forces

Interactive Discussion: Objective. Which of Newton's laws established where the frame of reference must be located?

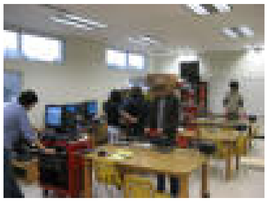
In Class Problem Solving:

1. Rail car problem

Homefun: prob. 23, 25 Serway

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Analysis of a Circular Motion on a Vertical Track
Purpose	Determine the height on the track's entrance ramp from which a roller must be released for it to make a complete circle without falling off the track.
Overview	1. Measure height from the top of the circle. 2. Run multiple trials for both the steel roller and the mouse roller (rubber surfaced)
Data, Calculations	Calculate an expected value for the height using energy equations and calculate a % difference between the expected value and the average value measured for each of the 2 rollers.
Questions, Conclusions	1. Why is the required height much greater than expected? Is it a problem with the mathematical model or just some form of random error or experimenter ineptitude? (Hint: If more energy was used than expected, it had to go somewhere. Click the button at the top labeled rotation and look for a possibility.) 2. Do both rollers have to start from the same height? If not, then why would one roller need to be started from a greater height than the other?
Resources/Materials:	circular track, steel roller, mouse roller, meter stick

Chapter 9: Linear Momentum and Collisions (Serway p. 251)



Students conducting a conservation of momentum lab using air tracks and computer collected data.

AP Physics C Newtonian Mechanics:

D. Systems of particles, linear momentum 12% cumulative 73%

1. **Center of mass**
2. **Impulse and momentum**
3. **Conservation of linear momentum, collisions**

Practice Test | Study Guide

Objectives

Essential Question: Would a rail-gun have recoil?

Momentum and Collisions

1. Define momentum 2 ways.
   a. How hard it is to stop an object
   b. P ≡ mv
2. State Newton's second law in terms of momentum.
3. Name two types of situations where momentum is conserved.
   a. **Explosions** - things flying apart
   b. **Collisions** - things flying together
4. State one of the key reasons momentum can be conserved. - It's a vector!
5. Solve 1 dimensional "explosion" problems using conservation of momentum.
6. Describe the difference between elastic and inelastic collisions.
   a. **Elastic:** bounce, KE conserved
   b. **Inelastic:** sticking, KE not conserved
   c. **Momentum is conserved for both**
7. Solve 1 dimensional inelastic collision problems using conservation of momentum.

Homefun: Read 9.1 and 9.3, Questions 1-10 p. 281; Problems 1, 3, 5, 19. Serway

Metacognition Problem Solving Principle 9.1: Solutions for final velocity of an object in one dimensional problems usually end up with a mass

Activities

Lesson 1

Key Concept: Conservation of momentum

Purpose: Understand how to use conservation of momentum in problem solving.

Interactive Discussion: Objective 1 - 4. Note that momentum is one of the great conservation laws of physics.

Demo 9.1: Objective 3b. Explain that the spheres-on-a-rod will exhibit conservation of momentum when dropped. On the way down the total mass is the combined mass of the spheres. On the way up, only the small sphere will rise. Guess what happens to its velocity?

Video Clip: Show a video clip of the rail gun scene in *Eraser.*

In Class Problem Solving:

1. Arnie fires the rail gun.
2. Bubba pushes Nancy.

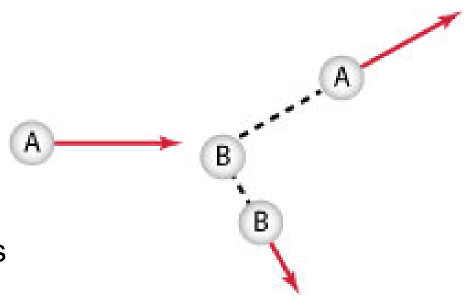
Demo 9.2: Demonstrate the

ratio time the starting velocity.

Essential Question: Why is it essential that collisions between molecules of air be elastic ?

Elastic Collisions

9. Describe in qualitative terms what happens in one dimensional elastic collisions.
10. Solve 1 dimensional elastic collision problems.
11. Solve problems inelastic collisions in 2 dimensions.
12. Solve problems involving elastic collisions in 2 dimensions.



When a mass collides with a stationary mass of the same size in a glancing elastic collision, the velocity vectors form a 90 degree angle afterwards.(p.270)

Metacognition Problem Solving Principle 9.2: The most complex vector problem can always be broken up into simpler 1 dimensional problems. Hence, The sum of momentums in each dimension after a collision has to be the same as the sum of momentums in the same dimension before the collision. - **Think components!**

Homefun: prob.15, 19, 21, 33, 37 Serway

Essential Question: Why is the conservation of kinetic energy for elastic collisions different from conservation of energy?

difference between elastic and inelastic collisions using happy and sad spheres.

In Class Problem Solving:

1. A moving train car collides with a stationary car.
2. Two meteors with different velocities collide and fuse.

Resources/Materials: spheres-on-a-rod, happy and sad spheres

Lesson 2

Key Concept: Conservation of Momentum With Elastic Collisions and in Two Dimensions.

Purpose: Expand the understanding of how conservation of momentum can be used for problem solving.

Demo 9.3: Objective 9. Demonstrate elastic collisions on an air track with combinations of various sized cars.

In Class Problem Solving:
Objectives 9

1. Derive an expression for the final velocities after the elastic collision of equal mass objects in one dimension.

Interactive Discussion: Objectives.

In Class Problem Solving:

1. When Bob meets Jane at an intersection
2. Bouncing billiard balls go boink.

Resources/Materials: Air track.

Lesson 3

Key Concept: Impulse

Impulse Section 9.2

12. Solve combined conservation of energy and momentum problems for inelastic collisions.
13. Solve combined conservation of energy and momentum problems for collisions involving springs.
14. Define impulse mathematically 2 different ways and explain in general terms what it indicates.

Metacognition Problem Solving Principle 9.3: Remember that **impulse obeys Newton's third law!** In other words, during a collision, the change in momentum caused by the impulse one object exerts on a second is exactly the same as the change in momentum caused by the impulse the second object exerts on the first.

Homefun: Read 9.2, prob. 6, 27, 57, 61 Serway

Essential Question: Why is center of mass important to martial artists?

Center of Mass Section 9.6

15. Find the center of mass of various objects.
16. State whether an object will rotate, translate, or both by looking at the location of forces relative to the center of mass.
17. Explain how center of mass relates to the stability of an object.
18. State what happens to the center of mass of an object when it explodes.

Metacognition Problem Solving Principle 9.4: Center of mass is like a balance point. By thinking of it in this manner, it's often possible to judge if a center of mass calculation makes sense by asking if the object would balance if suspended from

Purpose: Understand what happens during a collision.

Interactive Discussion: Objective 12. How much force can I take?

In Class Problem Solving: Objectives 12

1. Ballistic pendulum.
2. Bob and Jane play chicken with bumper cars (collisions with springs).
3. Bozo burns the rope on the bozomobile (releasing springs).

Interactive Discussion: Objectives. How much force can I take?

Demo 9.4: Demonstrate the effects of elastic and inelastic collisions on a block of wood using happy and sad sphere pendulums. Which has the higher impulse?

Resources/Materials: Happy and sad sphere pendulums.

Lesson 4

Key Concept: Center of mass

Purpose: Calculate the center of mass and use it as a problem solving concept in momentum problems.

Interactive Discussion: Objective 15. All of an object's mass can be considered to exist at it's center. How can the center of mass be found experimentally?

Demo 9.4: Objective 16. Throwing a meter stick. Throw a meter stick so that it rotates and so that it translates. What is the difference in how the force is applied?

Demo 9.5: Attempting to stand on

Homefun: Read 9.4 thru 9.6, prob. 39, 41 Serway

one leg. Stand with the feet spread apart shoulder width. Attempt to raise one foot and stand on only one foot without changing the position of your center of mass. (It can't be done)

Demo 9.5: Throwing an opponent who attempts to punch you (Aikido). Have a subject stand on one foot with the back leg extended backwards and extend his fist as far forward possible. This simulates the act of rushing forward while throwing punch. Have a second person very lightly pull forward on the wrist of the first person's extended arm. (This will very easily unbalance the first person. If the first person were actually rushing forward while throwing a powerful punch, he would be violently thrown to the ground with both translational and rotational motion)

In Class Problem Solving:

1. Masses on thin bars
2. Ls
3. Triangles

Essential Question: Why was the Apollo Rocket so huge?

Rockets and Explosions Section 9.6

19. State what happens to the center of mass of an object when the parts of an object are pulled together by an internal force (assuming no external resistance forces).
20. State what happens to the center of mass of a rocket (including its fuel) when it is accelerating in outer space.

Lesson 5

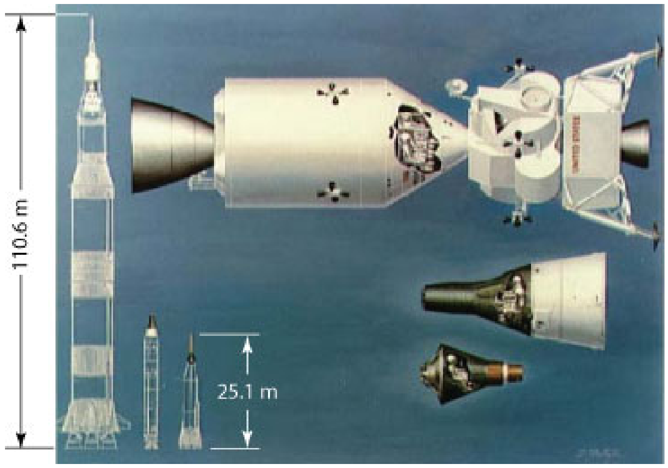
Key Concept: Propulsion using momentum and center of mass

Purpose: Understand how rockets work.

Interactive Discussion: Objectives.

Demo 9.4: Robot which propels itself by changing the location of its center of mass.

In Class Problem Solving: Thrust caclulations



21. Calculate the thrust produced by a rocket.

$$F_T = v_m \, dm/dt$$

22. State two reasons why a rocket must have a very large supply of fuel in order to move from the surface of Earth into outer space.

Metacognition Problem Solving Principle 9.4:
Remember that the center of mass of a system is only affected by external forces. Any form of explosion can be considered an internal force.

Homefun: Read section 9.7, prob. 43, 51 Serway

Formal Lab Investigation	
Title	Investigation of a Collision on an Air Track
Category	Linear momentum
Purpose	Determine if conservation of momentum can be observed in the collision of 2 sliders on an air track
Models	$SP_{before} = SP_{after}$ conservation of linear momentum
Overview	Momentum is conserved in a collision as long as there is not a friction force acting on the objects in a way that significantly reduces the velocities. Since an air track simulates a friction free environment, it should be an ideal test platform for conservation of momentum investigations. Level the air track so that the sliders remain stationary unless they

	are pushed. Place 2 sliders of equal mass on the track. Just before the collision, the one in back will be sliding toward the stationary one in front. Set up a pair of photogates so that the first measures the moving slider's velocity just before the collision and the second measures the velocity of the 2nd cart just after the collision. Gently push the slider in back, measure the results of the collision, and determine if conservation of momentum is a good model for the system.
Safety Issues	Air track motors can overheat if the air inlet is blocked.
Equipment Limitations	Air tracks an their sliders are much more delicate than they look. Do NOT drop or strike them
Resources/Materials:	Air track and slider, photogates, computer system set up with Vernier LabPro software and Lab Pro units

Mr. Rogers' AP Physics C: Mechanics Objectives				
Syllabus	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
Gravity	Circular Motion	Statics	Rotation	

Chapter 13: Universal Gravitation

AP Physics C Newtonian Mechanics:

F. Oscillations and gravitation 9%, cumulative 82%

4. Newton's law of gravity
5. Orbits of planets and satellites
   a. Circular
   b. General

Practice Test	Study Guide

Objectives	Activities
Essential Question: Do force fields really exist and are they similar to the force fields on Star Trek or Star Wars? 1. The Flat Earth Model of Gravity 2. Mathematically define gravity field. 3. Draw a ray diagram of a constant gravity	**Lesson 1** **Key Concept: Falling in Uniform** Gravity Fields **Purpose:** Introduce the concept of force fields using the most common force field

field.

4. State the meaning of the space between rays in a force field diagram.
5. State the two assumptions implicit in modeling the Earth's gravity field as constant.

- The Earth is flat
- The Earth's surface is infinitely large

6. Calculate terminal velocity for a falling object with air resistance and compare it to a falling object without air resistance. (see page 162)
7. Explain where air resistance comes from and why it should not be called air friction.

gravity. Show how a velocity dependent force like air resistance interacts with a constant gravity field.

Interactive Discussion: Star Wars vs. real life

In Class Problem Solving:

1. Derive an expression for calculating terminal velocity.

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Analysis of Low velocity Air Resistance for a streamlined and non-streamlined object
Purpose	Determine if air resistance is directly proportional to velocity for a streamlined and non streamlined object/
Overview	Air resistance is often modeled as being directly proportional to velocity when included in mathematical models using Newton's second Law.
Data, Calculations	Perform regression analysis on the the data for each object using Minitab and plot the residuals.
Questions, Conclusions	Was a linear relationship between air resistance and velocity appropriate? How did the streamlined object differ from the non streamlined one.
Resources/Materials:	Wind Tunnel and associated equipment.

Lesson 2

Essential Question: What causes non uniform force fields?

Gravity Fields Around Planets

Section 13.1, 14.2

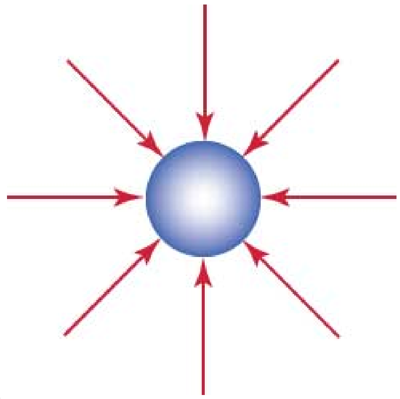
8. Correctly use the universal gravitational force

Key Concept: Non-Uniform Gravity Fields

Purpose: Introduce the concept of force fields and show how it can be used in problem solving.

equation.

- yields an action reaction pair
- r = distance between centers of mass
- G = universal gravitational constant
- the equation does not work inside a planet
- force is directly proportional to mass
- force is inversely proportional to r squared



9. Draw a ray diagram of the gravity field around a planet (see red lines in figure at right). Note tat the spacing of the lines is directly proportional to the g-field strength, if the drawing id made to scale.
10. Calculate the gravity field strength (acceleration due to gravity) using the universal gravitational force equation.
11. Note that the gravity field above a planet's surface acts as though it came from a point source located at the planet's center of mass.
12. Explain why the equation for gravity force vs. distance from a planet (a point source of gravity) is only valid above the planet's surface.

Homefun: Read 13.1 to 13.3; Problems 1, 3, 11, 23 p. 412 - 413 Serway

Interactive Discussion: Objectives

Demo 1: Demonstrate the inverse square law with a flashlight.

Video Clip: Show a video clip of Armageddon when the asteroid is split in half and travels around the Earth. Estimate the tidal forces casued by the asteroid as it travels within 300 miles of Earth's surface. (teams of 2)

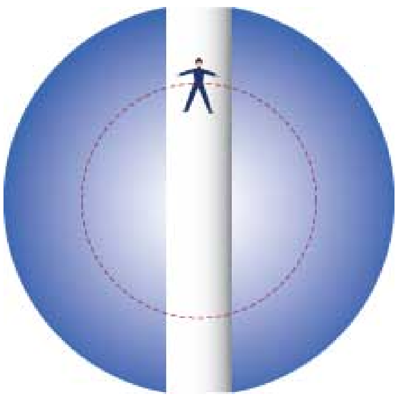
In Class Problem Solving:

1. Calculate g for planet Earth.
2. Calculate g for Zorg.

Resources/Materials: Flashlight

Essential Question: How can the force of gravity be calculated inside a planet?

The Ultimate Transportation System -- *a Tunnel Through the Center of a Planet.*



13. Define scaling factor.
14. Derive an expression for the gravity field vs. radius inside a planet, using the following:
    - the gravity field inside a hollow planet is zero
    - if an object's center of mass (CM) is at a distance r from the planet's CM, only mass in the sphere of radius r will create a net gravitational force.
    - the gravitational force is calculated using the universal gravity equation using the above sphere
    - mass scales with the cube of the scaling factor.

14. Using the displacement equation for simple harmonic motion as show below, derive the velocity and acceleration equations for simple harmonic motion.

$$x = (x_{max})\cos(wt)$$

15. Derive the time it would take to fall through a tunnel bored through the center of the Earth.
16. Plot a graph of g-field vs, distance from the center of a planet.

Homefun: Serway

Lesson 3

Key Concept: Gravity Field Inside a Planet

Purpose: Introduce scaling factors and show how scaling factors in combination with simple harmonic motion and the universal gravitational equation can be used to analyze the g-field inside a planet.

Interactive Discussion:

1. Describe the gravity field inside a hollow planet.
2. Describe the ultimate transportation system.

In Class Problem Solving:

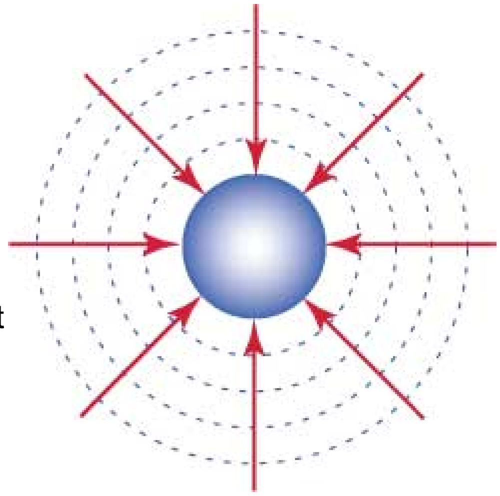
1. Derive an equation for the gravity field inside a planet.
2. Give the displacement vs. time equation for simple harmonic motion, derive the velocity and acceleration vs. time equations.
3. Calculate the time required to fall completely through a tunnel from one side of Earth to the other.

Essential Question: How is gravitational Potential energy calculated when the g-field is not constant?

Gravitational Potential Energy From a Planet

Lesson 4

17. Note that that by convention the gravitational potential energy is considered to be zero at a distance of infinity from a planet.



18. Using the definition of gravitational potential energy, derive an expression for gravitational potential energy vs. distance from the center of a planet, above the planet's surface. (Note blue dashed lines at right are constant potential energy lines.)
19. Explain why the equation for potential energy vs. distance from a planet (a point source of gravity) is only valid above the planet's surface.

Homefun: Read 13.4 to 13.6, Problems 27 p. 415 Serway

Metacognition Problem Solving Principle 13.1: When deriving a gravitational potential energy equation, remember it will come from an analysis of the work done to move an object, in other words, a gravity force expression times a displacement.

For example:

U = - **(force expression)** **(displacement)**

$= - ([G(m_2 m_1)] / r^2)\ (r)$

$= - m_1[G(m_2)/r]$

Key Concept: Potential Energy Around a Planet

Purpose: Relate gravitational potential energy to gravity force.

Interactive Discussion: How are gravity field lines related to constant potential energy lines?

In Class Problem Solving:

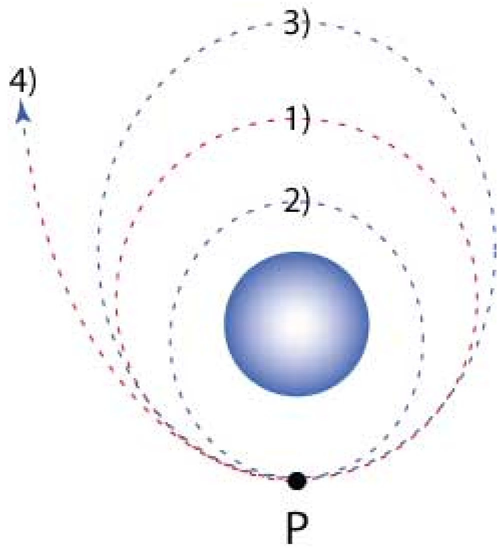
1. Derive an expression for potential energy vs distance from the center of a planet.

Essential Question: How can a spacecraft escape from a planet's gravity?

Lesson 3

Gravity and Orbits

Key Concept: Orbiting and Escaping



20. **Circular Orbit:** Calculate the velocity or radius (depending on what is given) for circular orbits by combining circular motion equations with the universal gravity equation.

$$v = [(GM_e) / r_e]^{0.5}$$

20. **Elliptical Orbit (speed lowered at P):** Describe what happens to a satellite in circular orbit if it's tangential velocity is decreased.
21. **Eliptical Orbit (speed increased at P):** Describe what happens to a satellite in circular orbit if it's tangential velocity is increased.
22. **Escape from Orbit:** Calculate escape speed from the surface of a planet. (p. 407)

$$v = [(2GM_e) / r_e]^{0.5}$$

20. State the two critical speeds for orbits.
21. Calculate the height of a geosynchronous orbit.

Homefun: Read 13.4 to 13.7, Questions 1-10 p. 411 - 412; Problems 41 Serway

from a Planet

Purpose: Derive the key equations associated with orbits.

Interactive Discussion: Objective s

Video Clip: Show a video clip of the Space Shuttle taking off from the surface of the asteroid in Armageddon. Calculate the escape velocity needed. How fast would the ship have to be moving to take off? Work in groups of two

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Wind Tunnel Fan's Torque Curve
Purpose	Determine the shape of the wind tunnel fan's torque vs. RPM curve.
Overview	Run the fan at various RPMs and record the wattmeter reading.
Data, Calculations	Using the above data, calculate torque for each RPM setting.

Questions, Conclusions	Using what you know about physics, attempt to explain the shape of the curve.
Resources/Materials:	Wind Tunnel, wattmeter, strobe light

Chapter: Statics

E. Circular motion and rotation (continued) 1% (estimated), cumulative 89%
2. Torque and rotational statics

Practice Test	Study Guide

Objectives	Activities

Essential Question: What do civil engineers do? Why did the Twin Towers collapse? (Remember this one?)

Statics (the second half of the story)

Section 12.1, 12.3

1. Define torque 2 ways:

- $\tau \equiv \mathbf{F} \times \mathbf{r}$
- A twisting action

2. Explain the difference between a vector dot product and cross product.

Note: the torque (τ = F x r) and work (w = F•r) equations look like they'd yield the the result same but one is a cross product and a vector. The other is a dot product and a scalar

3. State all of the requirement for a static condition to exist.

$$\Sigma F_x = 0, \Sigma F_y = 0, \Sigma F_z = 0$$

$$\Sigma \tau_{xy} = 0, \Sigma \tau_{yz} = 0, \quad \Sigma \tau_{zx} = 0$$

Note: We will typically work in only 2 dimensions (x, y)

Lesson 1

Key Concept: Static equilibrium

Purpose: Define and understand the conditions required for static equilibrium.

Interactive Discussion: Objectives

In Class Problem Solving:

1. Toto atop the storm cellar door
2. Luke Skywalker walks the plank.
3. Ed the restaurateur hangs his sign.
4. Bob's big bicept
5. Calculate mechanical advantage (what they didn't tell you in physical science class)

for forces and in only one plane (xy) for torque

Homefun: Problems 13, 15, 23, 57, 55. Serway

Metacognition Problem Solving Principle 6.1: When solving statics problems using torque equations the pivot point can be placed anywhere. Often the problem can be greatly simplified by placing it in a convenient location.

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Finding Center of Mass
Purpose	Find the center of mass of an odd shaped flat object
Overview	1. Hang an odd shaped flat object from a point on its edge so that it is free to pivot. hang a plumb line from the same point and draw the line on the flat object. 2. Repeat the above process from at least 3 different points. If done correctly, each of the plumb lines will pass through the center of mass. Where they intersect represents the center of mass.
Data, Calculations	1. Calculate the position (x, y coordinates) of the center of mass of the odd shaped object 2. Calculate a % difference between the measured and theoretical center of mass coordinates.
Questions, Conclusions	1. Estimate your experimental error in measuring the center of mass.
Resources/Materials:	Flat odd shaped objects, meter sticks, plumb lines

E. Circular motion and rotation (continued) 8% (estimated), cumulative 97%
3. Rotational kinematics and dynamics
4. Angular momentum and its conservation

Practice Test	Study Guide
Objectives	**Activities**

Essential Question: How is rotational motion related to linear motion?

Rotational vs. Linear Motion - Section 10.1, 10.2

1. State the rotational equivalents of the linear quantities mass (p. 301, see table 10.2 on p.304), velocity, acceleration, and force (p.306).
2. State the 2 types of vector multiplication and describe the differences between them.
3. For rotational inertia or moment of inertia, state the dominate effect, distance from the center of rotation or mass.
4. Convert between various methods of expressing rotational velocities.
5. Indicate which rotational quantities are vectors and which are scalars.
6. Use the right hand thumb rule to represent rotational vectors as arrows where the length is proportional to the magnitude and the arrow head represents the direction. (Figure 10.3, p. 295)
7. By looking at the arrows representing rotational velocity and acceleration, determine if an object's rotation is speeding up or slowing down.
8. By looking at the arrows representing rotational acceleration determine the direction of the arrow representing the torque vector.
9. By looking at a free body diagram of an object at rest, indicate whether the object will rotate or translate.

Lesson 1

Key Concept: Every quantity and equation in the linear world has a counterpart in the rotational world.

Purpose: Enable students to write rotational equations, given linear equations addressing similar situations.

Interactive Discussion: List the linear and their corresponding rotational quantities on the board.

In Class Problem Solving: see MiniLab below

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Analysis of Trinity's Kick (*The Matrix*)
Purpose	Determine if the fat cop kicked by Trinity in The Matrix would have flow straight backwards.
Overview	After viewing the Trinity's famous Kick in the Matrix, attempt to simulate it by striking the anthropomorphic dummy (Silent Bob) with the striking

	device (Jay). Note the motion of Silent Bob. Adjust Jay's blow so that Silent Bob does indeed fly across the room.
Data, Calculations	Record your observations an make free body diagrams of the two situations described above. Show all forces.
Questions, Conclusions	1. Describe the motion Trinity's kick should have induced in the fat cop. 2. If the motion of the cop was incorrect, then how did the moviemakers provide the forces to produce it? 3. Where and at what angle must Jay strike Silent Bob to make him fly across the room? Explain your answer.
Resources/Materials:	striking device (Jay), anthropomorphic dummy (Silent Bob), Matrix DVD

Essential Question: Can kinematic problems involve rotation?

Rotational Kinematics and Kinetic Energy

10. Solve problems with rotational kinematics equations.
11. Calculate rotational kinetic energy.
12. Solve problems with rotating objects going up inclines

Homefun: Questions 1-5 Problems 1, 3, 7. Serway

Metacognition Problem Solving Principle 10.1: For every linear motion equation & principle there's a rotational counterpart. If you know the equations and principles of motion in the linear world you know them in the rotational world.

Lesson 2

Key Concept: Rotational kinematics

Purpose: Enable students to solve rotational kinematics problems..

Interactive Discussion:

In Class Problem Solving: Objectives

1. State the Earth's rotational velocity in RPM, RPS, tangential velocity, and ω.
2. Spin down time on a wheel.
3. Swinging door problem. $\theta = 2t^3 - 3t^2 + 5t + 7$, Find θ, ω, α @ t=10 sec
4. Calculate the rotational kinetic energy stored in Earth both in joules and megatons of TNT. (1.0 megaton of TNT = 4.184×10^{15} joules.)

Essential Question: How does rotational inertia differ from linear inertia?

Rotational Inertia - Section 10.5

13. State the general form of the rotational inertia equation.

Lesson 3

Key Concept: Unlike linear inertia, rotational inertia depends on the distribution of mass.

$$I = \int x^2 \cdot dm$$

14. Calculate the rotational inertia of a rod rotating about an axis at its end.
15. Calculate the rotational inertia of a rod rotating about an axis at its center.
16. Calculate the rotational inertia of a disk rotating about an axis through its center.
17. Use the **parallel axis theorem**. (cm indicates center of mass, D = distance from cm)

$$I = I_{cm} + mD^2$$

Essential Question: Can a class of problems look entirely different but still have the same equations?

Yo-yos and Pulleys - Section 10.3

18. State the two key equations which link the linear and rotational worlds.
19. Given a wheel's w solve for its linear velocity and vice versa.
20. Given a wheel's a solve for its linear acceleration and vice versa.
21. Find the net torque on a wheel.
22. Use the rotational version of Newton's second law. (See example 10.9, p.307.)
23. Calculate the max torque which can be exerted on a wheel without making it spin.
24. Solve yo-yo problems involving the rotational version of Newton's 2nd Law.
25. Solve yo-yo problems using conservation of energy.
26. Solve pulley problems. (See example 10.12, p.310.)

Metacognition Problem Solving Principle 10.2: There's an equation which links the linear world to the rotational world for every property of

Purpose: Learn to calculate rotational inertia

Demo 10.2: Objective 1, 400 grams of mass taped on the end of a meter stick. Have students balance the mass on their hand first with the mass close to the hand and second with the mass as far as possible from the hand. Which way is easier and why?

Interactive Discussion: Objective

In Class Problem Solving: Objectives

1. Rod rotating around end.
2. Rod rotating around center.
3. Disk rotating around center.

Resources/Materials: Meter stick, tape, and 2, 200 gram weights.

Lesson 4

Key Concept: There are three key equations which link the linear and rotational worlds.

Purpose: Show how rotation and linear motion interact.

Demo 10.3: Pull a yo-yo on a table with the string up and down. Predict the motion.

Interactive Discussion: Objectives.

In Class Problem Solving:

1. Hanging yo-yo.
2. Yo-yo as pulley
3. Yo-yo as rod

motion in physics.

1) $x = r\theta$
2) $v = r\omega$
3) $a = r\alpha$
4) $\tau = (F) \times (r)$

Metacognition Problem Solving Principle 10.1: In a yo-yo problem generally use the linear and rotational versions of Newton's second law i nothing has changed its potential of kinetic energy. Otherwise, look first at the possibility of writing an energy balance.

Homefun: prob. 33, 35, 37, 59 Serway

Essential Question: Can different parts of the same rigid object fall with different accelerations and can they be higher than g?

Swinging Rods and Belts - Section 10.3

27. Solve swinging rod problems involving the rotational version of Newton's 2nd Law.
28. Explain why different parts of a swinging rod can "fall" at different accelerations with some parts falling faster than g.
29. Solve swinging rod problems using conservation of energy.
30. Calculate the power required to turn a winch.
31. Solve belt problems.

Homefun: prob. 45, 47 Serway

Lesson 5

Key Concept: Rotational Work, Power, and Energy

Purpose: Apply conservation of energy to rotational problems

Interactive Discussion: Objectives

In Class Problem Solving:

1. Swinging rods

Formal Lab Investigation	
Title	Investigation of a Belt Drive
Category	Rotation
Purpose	Determine if the belt on a 5.25 inch floppy disk drive is slipping.

Models	V = r(□)
Overview	Use a strobe light to measure the rotational velocity of the wheels in a floppy disk drive.
Safety Issues	Do not flash the strobe in anyone's eyes. Do not short circuit the power supplies. They can burn up. Do not touch any pieces of rotating equipment. This can seriously injure fingers.
Equipment Limitations	The floppy drives can be damaged if run too fast for a long period of time.
Resources/Materials:	strobe light, old floppy disc, 12 volt power supply, two connecting cables.

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Analysis of Two Pendulums
Purpose	Find the difference in the natural frequencies of 2 pendulums of equal length but unequal rotational inertia.
Overview	Calculate the rotational inertial and the natural frequencies of both pendulums. Measure the natural frequency of both.
Data, Calculations	Calculate % difference between the predicted and actual natural frequencies of the 2 pendulums.
Questions, Conclusions	Why do the two pendulums have a different natural frequency?
Resources/Materials:	string and weight, rod pivoted at one end

Essential Question: Can an object in linear motion be modeled as though it is rotating?

Rotational Momentum

32. Solve for the rotational velocity of a rotating object when the moment of inertia changes.
33. Solve rod and mass collisions.

Lesson 6

Key Concept: Rotational momentum

Purpose: Apply conservation of momentum to rotational problems

Demo 10.4: Spin a student in a chair with arms outstretched and holding dumbbells. Have them draw the dumbbells in. Why do they speed up?

Interactive Discussion:

In Class Problem Solving:

1. Ice skater problem

2. Rod and mass collisions

Mr. Rogers' AP Physics C: IB Physics Topics				
Syllabus	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
AP Review				

Mini-Lab Physics Investigation (Requires only Purpose, data, and conclusion)	
Title	Analysis of Mr (name 0mitted)' Back-Yard Trebuchet
Purpose	Find the take off velocity and angle and the maximum height of a typical water balloon fired from the trebuchet in Mr. (name 0mitted)' back yard (why Mr. (name 0mitted)' neighbors love him).
Overview	You can only use the devices listed below and must submit a written procedure before running the experiment.
Data, Calculations	Calculate the take off velocity and angle and the maximum height.
Questions, Conclusions	1. Why does the mass of the water balloon make a difference? 2. Does changing the weight on the trebuchet affect its efficiency? How do you know?
Resources/Materials:	stop watch, range finder, a 250 ml beaker, funnel

AP Test Review

The AP Test Review Process

Most of the 4th quarter will be devoted to AP test Review. While a full quarter for review may sound like a lot, keep in mind that the test will be in May, hence, we will lose about a month of possible classroom time. Also we lose a week for

What it takes to Pass the AP Test

The AP Physics C test is the toughest test offered (based on correlations between PSAT scores and AP passing rates). Not only is it a difficult test but it has a great deal of time pressure. Do not be deceived by the low scores required for passing, the test is hard to pass.

On the other hand, with commitment, passing the AP spring break in the 4th quarter.

Passing the AP test is a goal worthy of review time, however, review is also an excellent way to gain a deeper understanding. Unlike earlier home work and class work problems, AP test problems often merge several problem types into a single problem with multiple steps. In many cases, it's not possible to work these problems until most of the subject has been covered.

See below for more details on the review process.

Physics test is not only doable but is a badge of honor that will be noticed by college recruiters. Whether you pass or not, you will definitely be better off for having made the effort.

AP Physics C Mechanics Scores

AP Grade	1988 % Correct	1993 % Correct	1998 % Correct	2004 % Correct
5	62-100	66-100	61-100	54-100
4	48-61	51-65	48-60	42-53
3	34-47	38-50	36-47	31-41
2	21-33	23-37	23-35	20-30
1	0-20	0-22	0-22	0-19

Free Response Question Preparation

Daily Class Work: You will work a minimum of 9 sets of free response problems from old tests in class on the white board at the front of the room under Mr. (name omitted)' guidance. All problems will be graded as you complete them. You will be asked to keep a running tally of your scores to continuously ascertain your extent of readiness. Mr. (name omitted) will re-teach material as deemed necessary. Problem sets can be found online at the AP Physics C Mechanics section of the American College Board site or will be provided by Mr. (name omitted).

To get the best benefit from the in-class practice you will need to re-work as homework any problems you had difficulty with. It is often better to return to the same problem multiple times and completely understand it than work problem after problem with only partial understanding.

Quizzes: Mr. (name omitted) will periodically give quizzes on free response problems. These will consist of a free response problem selected at random from those that have been worked. Quizzes will not be curved and will count 15 points each just like those on the AP test.

Multiple Choice Question Preparation

Weekly In-Class Tests: An actual multiple choice AP test from previous a year will be given approximately once per week starting near the end of March (four tests total). These will count 100 points each toward your grade. They will be curved to approximate an AP grading system. At worst 50% correct will be a "C". In addition, each student will receive an estimate from 1 to 5 of their future grade based on each test.

Take-Home Tests: A minimum of 2 multiple choice AP-type take-home tests will be given. These will count 50 points each and may be curved but not as generously as the in-class tests. Your work is to be turned in on each question. You may collaborate with other students and may compare answers but only if each person has actually worked the problem and written down their work. Allowing a student to simply copy your answers is strictly forbidden and may result in a grade of zero for both of the students involved.

The Good News: The highest in-class test will be cloned to help compensate for having a bad day. Take-home tests will not be cloned.

Out-of-Class Guided Study Sessions

Mr. (name omitted) will typically offer numerous after school and Saturday guided study sessions. He has free response test sets going back to 1973 as well as additional study books other than the Barron's and Princeton Review books. There is little chance of running out of materials. Anyone whose test and in class practice grades falls below those needed for passing the AP test is expected to attend.

Self Study

As mentioned on the first page, you will not reach your potential on the AP test without a lot of self study. This AP test study should start in December. At that time you should be practicing the multiple choice practice tests in the Barron's AP review book provided by Mr. (name omitted). These questions are close to those actually found on AP tests.

In March you should begin working multiple choice practice problems in the Princeton Review book you have purchased. Mr. (name omitted) recommends that you read the entire section of the Princeton Review book's section on AP Physics C Mechanics some time in April.

After the AP Exam

Typically we will have a few weeks left after the AP Test. Students will be required to attend class during this time. First we will catch up on any physics we are behind on. In the event that we are totally caught up, we will start on next years topics.